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CONTAMINATION OF DIAGNOSTIC OPHTHALMIC SOLUTIONS IN PRIMARY EYE CARE SETTINGS

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree, Doctor of Optometry
School of Optometry
University of California, Berkeley

By

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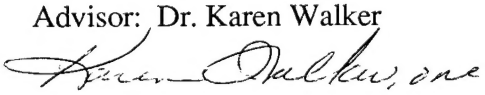

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CONTAMINATION OF DIAGNOSTIC OPHTHALMIC SOLUTIONS IN PRIMARY EYE CARE SETTINGS

ABSTRACT

Pharmaceutical agents and irrigating solutions are widely used in both optometric and ophthalmologic practices. Contamination of these containers or solutions could possibly pose a danger to the patient. We set out to investigate the possible contamination of a representative sample of these containers in small office practices.

Two diagnostic pharmaceutical agents and an irrigating solution used in primary care optometric and ophthalmologic practices in the San Francisco-Oakland Bay Area were tested to investigate the rate of contamination and to identify the types of microorganisms in the contaminated solutions. Sixty total samples (proparacaine, tropicamide, and an irrigating solution) were randomly cultured and 11.7% of the samples showed contamination. *Pseudomonas cepacia*, *Staphylococcus epidermidis*, *Pseudomonas putida*, and *Streptococcus* species were the predominant organisms isolated from the contaminated bottles. In addition, 17 of the original 60 containers were cultured for investigation of the dried residue particles around the threads of the containers. Of these 17 investigated, 13 (76.5%) tested positive for staphylococcus and micrococcus species.

INTRODUCTION

In this study we investigated the contamination rate and use of multi-drop eye bottles in primary care settings. Previous studies had only been conducted on bottles collected in large hospitals or in a controlled lab environment. The primary care settings used in this study were optometry and ophthalmology clinics. Our study is the first that we know of that investigated the typical small eye care practitioner office. In addition, we utilized specific species identification and quantification through a cellular fatty acid analysis using gas liquid chromatography. Our study took the cultures from commonly used diagnostic pharmaceutical agents (DPA's) common to most of these offices. Specifically we looked at tropicamide preserved with 0.01% benzalkonium chloride (B.A.K.), 0.5% proparacaine hydrochloride preserved with B.A.K. 0.01%, and extraocular irrigating solutions such as Blinx preserved with 0.005% B.A.K and 0.02% EDTA.

We visited 17 primary care clinic sites and cultured the bottles that were in use at that time. Since different offices use different brand names it was not always possible to get the same brand of DPA at each site, but it was possible to obtain these widely used drugs at all sites.

The ocular irrigating bottles were plastic squeeze bottles with a capacity of 120 ml. The DPA's were dispensed in a plastic squeeze bottles of 15 ml capacity. It had been reported in the literature that plastic squeeze bottles were more prone to contamination near the bottle cap, since this area was "dead space" which allowed for bacteria to grow because there is not adequate preservative at this "dead space". In the case of pipette type dispensers, the pipette tip is immersed in the solution after use, thereby, immersing any adhering bacteria in the preservative and killing them.

In addition to culturing random containers, we attempted to obtain information regarding the use, administration and care of DPA's within each participating clinic.

There have been many studies concerning the contamination rate of multi-drop eye bottles. Most of the studies have found a very low rate of contamination and little to no relation regarding the length of time the bottle has been used, (Hovding[8], Coad et.al.[5], Aslund et.al.[2], Stevens et.al.[11]). However in one study, Harte et.al.[7] found a 27% contamination rate for phenylephrine preserved in benzalkonium chloride 0.01%. Some of these studies inoculated the bottles with a bacterium such as *Pseudomonas aeruginosa* and were cultured at various time intervals, while others took cultures without inoculating the sample.

Surveys have been conducted in British hospitals[7,11] to evaluate the incidence of microbial contamination in topical ophthalmic medications. One of the surveys[11], which was done at Moorfields Eye Hospital, revealed 5 contaminated eyedrop bottles out of 216. The organisms cultured from these bottles included *Staphylococcus epidermis* and *Staphylococcus aureus*. In the other survey[7], residues of eyedrops and eye ointments taken from a Dublin hospital were examined; contamination was found in 44% of eyedrop samples and in 36% of ointment residues. This survey also showed 37% contamination in solutions which contained bactericide.
Other studies[1,2,3,10,13] have found bacterial growth in contaminated ocular medications and irrigation solutions. *Pseudomonas aeruginosa, Serratia marcescens*, and *Proteus mirabilis* have all been isolated from topical ocular medications such as timolol maleate. These gram negative organisms were responsible for severe keratitis present in seven cases studied.[10]

Templeton et.al.[12] cultured *S. marcescens* from the dead space in eyedropper caps and grooves of the bottle tops of ocular medications. They claim that moisture, which collected in the dead space between the cap and bottle, served as a potential culture medium for Serratia.
Studies of Fluress[5,6] have shown that no bacteria can be recovered from these bottles. Fluress solutions were inoculated with *P. aeruginosa* and *S. aureus*, but no organism could be recovered from either the solution or dispensing tip[6]. Fluress contains 1% chlorobutanol and its sterility and anti-microbial properties are attributed to this preservative.

The design of the eyedropper bottle also had a role in the contamination of drops because in clinic, the dropper tips of eyedrop bottles are the entry of exogenous organisms and these tips are frequently contaminated[5]. It was shown that a pipette nozzle decreased the risk of microbial contamination and growth. There were no organisms present in pipette aspirates[8]. The source of organisms was the lid margins and fingers.

The stability and efficacy of ophthalmic solutions, which are fortified with antibiotics, was studied[4]. It was shown that cefazolin and tobramycin remained stable for 4 weeks and maintained its efficacy throughout the study.

Aslund et.al.[2] showed that the frequency of contamination was insignificant when aseptically trained personnel administered the eyedrops, whereas in untrained personnel the rate of contamination of eyedrops was 25%.

METHODS and MATERIALS

Sources of DPA samples

Seventeen offices in the San Francisco Bay Area were selected to provide 60 DPA samples. The offices selected included both optometric and ophthalmologic practices. All collection was performed on 3-14-94 using refrigerated transport containers and all randomly selected samples were cultured the next day. The pharmaceutical agents tested included 20 bottles each of the following solutions:

1. Irrigating solution
2. Proparacaine 0.5%
3. Tropicamide 0.5 - 1.0%

The containers tested were being currently used in the practice and were between 1/4 and 3/4 full. Sealed, unopened bottles of each pharmaceutical agent were tested as controls.

Microbiological Assays

In order to test the suitability of the test methods, challenge organisms were added to product/media mixtures. The concentration of each ophthalmic product in the test media was the same as that resulting from the actual inoculation of unknown test samples. No inhibition of

growth was detected when the following challenge organisms were seeded into each of the 3 types of unopened product/media mixtures:

Pseudomonas aeruginosa
Bacillus cereus

Uninoculated controls on all of the media were incubated in the same manner as the test samples and no growth was obtained. The laminar flow biological safety cabinet was operating under the NSF-49 Standard during the inoculation of the test samples. When 1 square foot of agar surface was exposed inside the cabinet for 1 hour, no colonies were observed after incubating the agar at 35°C for 2 days.

All DPA samples were cultured in the same manner and all primary inoculations were done in a laminar flow biological safety cabinet operating under class 100 conditions. Each sample bottle was shaken 25 times in a one foot arc for 7 seconds. Two drops (0.1 ml) from each bottle were placed on the surface of a modified letheen agar plate. The inoculum was then spread to cover the plate surface. One drop from each bottle was then streaked for isolation on blood agar plates. The dropper tip and inner surface of the bottle cap were both scrubbed with a sterile, pre-moistened swab which was then placed into a tube of modified letheen broth.

All plate cultures were incubated at 30°C for 48 hours before examination for growth. Countable (15 to 150 colony forming units or CFU) letheen agar spread plates were counted and the results recorded as CFU per ml (count x 10). The letheen broth cultures were incubated at 30°C until growth appeared or for up to 7 days in the case of no growth.

Representative colonies of each type observed on the letheen and/or blood agar plates were picked, subcultured, and identified. Growth-positive letheen broth tubes were streaked onto blood agar plates for further isolation. Isolates were identified to species using a combination of conventional biochemical tests and cellular fatty acid analysis via gas-liquid chromatography.

In addition to testing the actual ophthalmic product solutions, tests were also done on particles of dried residual solution that were observed around the threads of 30% of the product containers. The particles appeared to be fairly friable and often would drop off during product dispensing.

Along with our selection of samples, we surveyed several local optometry and ophthalmology practices regarding their use of DPA bottles. In particular, our focus addressed DPA types, routine usage, storage, instillation, and record keeping.

RESULTS

Laboratory examinations were completed on the 60 ophthalmic solution samples submitted on 3-14-94. All of the samples were cultured on 3-15-94. The samples and results are as follows:

Eye Wash Solutions:

Sample#	Brand Name	Lot#	Expiration Date
94L00001	Blinx	H227C	08-94
94L00002	Blinx	H227C	08-94
94L00003	Blinx	H227C	08-94
94L00004	Blinx	H227C	08-94
94L00005	Blinx	H227C	08-94
94L00006	Blinx	H227C	08-94
94L00007	Blinx	H227C	08-94
94L00008	Blinx	H227C	08-94
94L00009	Blinx	H227C	08-94

94L00010	Blinx	H227C	08-94
94L00011	Blinx	H227C	08-94
94L00012	Blinx	H227C	08-94
94L00013	Blinx	H227C	08-94
94L00014	Renu	GA372	01-95
94L00015	B&L Sensitive Eyes Plus	GM340A	12-95
94L00016	Eye Stream	3ATN	01-96
94L00017	Eye Stream	3ATN	01-96
94L00018	Eye Stream	1LAM	09-94
94L00019	Soft Wear	20241	06-97
94L00020	"Home-made" saline	None	None

Growth was obtained from 2 of the eye wash samples as follows:

Sample#	Aerobic Plate Count, CFU/ml	Predominant Organism Isolated	Other Isolates
94L00018	1.2×10^3	*Streptococcus spp., Viridians group*	None
94L00020	2.1×10^4	*Burkholderia cepacia (Pseudomonas cepacia)*	*Pseudomonas putida*

Proparacaine Solutions:

Sample#	Brand Name	Conc.	Lot#	Expiration Date
94L00021	Spectro-Caine	1.0%	1144E	05-94
94L00022	Spectro-Caine	1.0%	1199E	09-94
94L00023	Spectro-Caine	1.0%	1144	05-94
94L00024	Spectro-Caine	1.0%	1269	11-94
94L00025	Spectro-Caine	1.0%	1144	05-94
94L00026	Spectro-Caine	1.0%	1269	11-94
94L00027	Spectro-Caine	1.0%	1115	05-94
94L00028	Spectro-Caine	1.0%	1144	05-94
94L00029	B&L	1.0%	1138	05-94
94L00030	B&L	1.0%	1138	05-94
94L00031	B&L	1.0%	1321	12-94
94L00032	Ophthetic	1.0%	4428U	03-94
94L00033	Ocusoft	1.0%	1118	04-94
94L00034	Spectro-Caine	1.0%	0195	02-93
94L00035	B&L	1.0%	0368	06-93
94L00036	B&L	1.0%	1100	04-94
94L00037	Alcaine	1.0%	2SBBE	08-94
94L00038	B&L	1.0%	1100	04-94
94L00039	Spectro-Caine	1.0%	1314	12-94
94L00040	Spectro-Caine	1.0%	1144	05-94

Growth was obtained from 4 of the Proparacaine samples as follows:

Sample#	Aerobic Plate Count, CFU/ml	Predominant Organism Isolated	Other Isolates
94L00025	$> 6.5 \times 10^4$	*Pseudomonas putida*	None
94L00027	3.0×10^3	*Pseudomonas putida*	None
94L00031	10	*Staphylococcus epidermidis*	None
94L00036	10	*Staphylococcus epidermidis*	None

Tropicamide Solutions:

Sample#	Brand Name	Conc.	Lot#	Expiration Date
94L00041	Steris Labs	1.0%	93C470	09-94
94L00042	Mydriacyl	0.5%	2RECM	05-94
94L00043	Mydriacyl	0.5%	2RECM	05-94
94L00044	Mydriacyl	0.5%	2RECM	05-94
94L00045	Mydriacyl	1.0%	2RDV	04-94
94L00046	Mydriacyl	1.0%	2RMAT	11-94
94L00047	Mydriacyl	1.0%	2RMAT	11-94
94L00048	B&L	0.5%	0709	12-94
94L00049	Mydriacyl	0.5%	2RAM	12-94
94L00050	Mydriacyl	0.5%	2RECM	05-94
94L00051	Mydriacyl	1.0%	2SCAR	03-94
94L00052	Mydriacyl	0.5%	2RECM	05-94
94L00053	Mydriacyl	0.5%	2OFAC	06-92
94L00054	Spectro-Cyl	0.5%	2A121	01-94
94L00055	Opticyl	1.0%	2F981	06-95
94L00056	Mydriacyl	1.0%	2RNAU	11-94
94L00057	B&L	1.0%	0687	12-94
94L00058	B&L	1.0%	0793	02-95
94L00059	Spectro-Cyl	1.0%	3E721	05-96
94L00060	B&L	0.5%	1213	03-96

Growth was obtained from 1 of the Tropicamide samples as follows:

Sample#	Aerobic Plate Count, CFU/ml	Predominant Organism Isolated	Other Isolates
94L00042	1.7×10^2	*Micrococcus luteus*	Budding yeast

Controls:
In order to test the suitability of the test methods, the challenge organisms *Pseudomonas aeruginosa* and *Baccillus cereus* were added to product/media mixtures. The concentrations of each ophthalmic product in the test media was the same as that resulting from the actual inoculation of unknown test samples. No inhibition of growth was detected when the following challenge organisms were seeded into each of the 3 types of unopened product/media mixtures. Uninoculated controls on all of the media were incubated in the same manner as the test samples. No growth was obtained.

The laminar flow biological safety cabinet was operating under the NSF-49 Standard during the inoculation of the test samples. When 1 square foot of agar surface was exposed inside the cabinet for 1 hour, no colonies were observed after incubating the agar at 35°C for 2 days.

In summarizing the data, microbial growth was obtained in 7 out of the 60 samples tested. Table 1 demonstrates the contamination rate of each of the DPA's tested.

TABLE 1. Frequency of contamination of DPA's used in primary eye care settings.

DPA	% Contamination	Confidence Interval
Irrigating solution	10% (2/20)	90% Confidence Interval 11.7%
Proparacaine	20% (4/20)	90% Confidence Interval 15.5%
Tropicamide	5% (1/20)	90% Confidence Interval 8.4%
Total	11.7% (7/60)	95% Confidence Interval 4.1%

All positive and negative control DPA solutions were free of contamination.

The organisms found in the contaminated samples were primarily Pseudomonas, Streptococcus, and Staphylcoccus species. Table 2 lists the predominant microorganisms in each of the contaminated samples.

TABLE 2. Predominant organisms isolated from contaminated samples.

DPA	CFU/ml	Predominant organism
Irrigating solution 1	1.2×10^3	*Streptococcus spp. (Viridians group)*
Irrigation solution 2	2.1×10^4	*Pseudomonas cepacia**
Proparacaine 1	$>6.5 \times 10^4$	*Pseudomonas putida*
Proparacaine 2	3.0×10^3	*Pseudomonas putida*
Proparacaine 3	10	*Staphylococcus epidermidis*
Proparacaine 4	10	*Staphylococcus epidermidis*
Tropicamide	1.7×10^2	*Micrococcus luteus**

*Other isolates were found in these samples. *Pseudomonas putida* was found in irrigating solution 2. A budding yeast was found in the tropicamide solution.

In addition to testing the actual ophthalmic product solutions, cultures were also performed on particles of dried residual solution that were observed around the threads of 17 of the product containers. These dried residue particles appeared to be fairly friable and often would drop off during product dispensing. When these particles were allowed to drop into plates of culture media, growth of bacteria was very often obtained. Results of testing these 17 sample containers with dried residues showed growth from 13 of the samples. The following organisms were cultured from these samples:

Micrococcus luteus was cultured from 8 sample bottles
Staphylococcus epidermidis was cultured from 3 sample bottles.
Micrococcus lylae was cultured from 1 sample bottle.
Staphylococcus warneri was cultured from 1 sample bottle.

Of the 60 sample solutions tested, 6 were being used beyond their expiration dates despite a visible label. None of these 6 expired solutions were found to be contaminated. However, the home-made saline solution sample tested positive for contamination and the age of this solution could not be established.

STATISTICAL ANALYSIS

We found that out of a total of 60 sample bottles collected, 7 solutions were contaminated. This yields an 11.7% contamination rate for the sample solutions in our study. The 60 samples included 20 bottles each of proparacaine, mydriacyl, and an eye wash/rinsing solution. Of the 20 eye wash solutions tested, 2 were contaminated giving a 10% contamination rate. The mydriacyl solutions yielded only 1 contaminated sample giving a 5% contamination rate. The highest percentage of contamination was found in the proparacaine samples with 4 out of 20 solutions being tainted yielding a 20% contamination rate. This is interesting since the proparacaine solutions are preserved with twice the amount of BAK that eye wash solutions are generally preserved with.

Analysis of the total samples can yield a 95% confidence interval rate for the 60 samples tested in this study. This and all other confidence interval rates were determined by assuming that the samples represent a binomial distribution that approximates the hypergeometric distribution of the actual sample size. Mathematically this is represented by the equation:

$$\rho - (2\alpha/2)\sqrt{(\rho q/n)} < p < \rho + (2\alpha/2)\sqrt{(\rho q/n)}$$

Where r is the proportion of successes (in this case the rate of contaminated sample solutions) in a random sample size n, and q= 1-ρ. The value α is taken from a hypergeometric distribution that represents chosen value of the confidence interval. Thus, we can determine a value p which represents the interval of successes that determines a 95% confidence interval:

$$0.1167 - 1.960\sqrt{((0.1167)(0.8833)/60)} < p < 0.1167 + 1.960\sqrt{((0.1167)(0.8833)/60)}$$
$$\text{or}$$
$$0.0752228 < p < 0.1581105$$

Therefore, we are 95% confident that our total sample size which yielded an 11.7% contamination rate differs from the true proportion by less than 0.04144 or about 4%.

Similar statistical analysis was performed on the rinsing solution samples, the proparacaine samples, and the tropicamide samples as follows:

A 90% confidence interval analysis for the rinsing solution samples yields:

$$(0.10) - (1.729)\sqrt{((0.10)(0.90)/20)} < p < (0.10) + (1.729)\sqrt{((0.10)(0.90)/20)}$$
$$\text{or}$$
$$0 < p < 0.21598$$

Therefore we are 90% confident that our rinsing solution sample size, which yielded a 10.0% contamination rate, differs from the true proportion by less than 0.11598 or about 11.6%.

A 90% confidence interval analysis for the proparacaine samples is as follows:

$$(0.20) - (1.729)\sqrt{((0.20)(0.80)/20)} < p < (0.20) + (1.729)\sqrt{((0.20)(0.80)/20)}$$
$$\text{or}$$
$$0.0453535 < p < 0.354646$$

Therefore we are 90% confident that our proparacaine sample size, which yielded a 20.0% contamination rate, differs from the true proportion by less than 0.1546 or about 15.5%.

Finally, a 90% confidence interval analysis for the tropicamide samples is as follows:

$$(0.05) - (1.729)\sqrt{((0.05)(0.95)/20)} < p < (0.05) + (1.729)\sqrt{((0.05)*(0.95)/20)}$$
$$\text{or}$$
$$0 < p < 0.13426$$

Therefore we are 90% confident that our proparacaine sample size, which yielded a 5.0% contamination rate, differs from the true proportion by less than 0.08426 or about 8.4%.

DISCUSSION

The presence of microorganisms in 7 of 60 samples tested suggests contamination of these samples. The samples contain benzalkonium chloride (BAK) as preservative. Contamination of ophthalmic eyedrops preserved with BAK has been observed in other studies [7,10]. The efficacy of this preservative is questionable, however, Aslund et.al.[2] showed that the handling of eyedrops by untrained people contributed significantly to the rate of contamination in eyedrop solutions, but when the eyedrops contained BAK, the contamination rate was significantly reduced. When

eyedrops are instilled by people who are trained in aseptic procedures there was no contamination of unpreserved eyedrops. Thus, the handling of eyedrops is the key to the contamination of ophthalmic eyedrops.

The lids, lashes, conjunctiva, and adnexa contain bacteria from birth throughout life. Common bacteria found in the lids, lashes, and conjunctiva of all ages include; *Staphylococcus epidermis*, *Staphylococcus aureus*, and diphtheroids[9]. Other microorganisms that have been cultured from the lid and lash margins and conjunctiva include; *Streptococcus viridians*, *Diplococcus pneumonia*, *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus vulgaris*, *Proteus mirabilis*, *Neisseria sicca*, *Bacillus subtilis*, *Bacillus cereus*, *Micrococcus tetragenus*. The bacteria cultured from ocular tissues are similar to those found on the skin and in the upper respiratory tract. It is possible that the skin of the face is an important source of contamination to the eyes. The nose and hands are also potential sources of contamination to the eye. Similarly, the eyes, lids, lashes, conjunctiva, adnexa, and hands are all potential sources of contamination for ophthalmic eyedrop solutions.

Pseudomonas species are not part of the normal ocular flora, but they have been associated with infections especially in compromised hosts. They are ubiquitous in soils, water, and plants so their presence in contaminated samples is transmitted by the hands.

As shown by Aslund et.al.[2] the use of aseptic procedures greatly decreases the frequency of contamination. Training personnel in the aseptic instillation of eyedrops would significantly reduce contamination. Contaminated eyedrops are a potential source of ocular infection, but the risk of developing infection is much greater and important in patients with compromised corneas such as post-operative patients, contact lens wearers, and patients with external eye disease. Obviously, proper medication instillation procedures should be used such as those outlined in various professional eyecare procedures texts.

Microorganisms have also been isolated from the residual particles that are left on eyedrop container tips or caps in this study. It is, therefore, advisable to remove the residues and particles before instillation of eyedrops by shaking them off the bottle or by occasional aseptic cleaning and sterilization procedures using alcohol or hydrogen peroxide solutions. Furthermore, to prevent formation of dried residue particles, the bottle tips and caps should be wiped off with sterile cotton wound applicators or alcohol wipes on a regular basis. Also, it might be suggested that discarding a single drop of solution prior to patient instillation could loosen the dried residue on the container tip thus reducing the likelihood of inoculating the patient's eyes with a contaminating organism.

Other recommendations that will help reduce contamination of opened eyedrops containers include; refrigerated storage, recapping the bottles after each use, marking the date when bottles are first opened, and discarding the containers after being contaminated by touching the patient's lids or lashes. Opening new solution bottles is the safest option when working with patients having compromised corneas. Discarding of solutions used on patients with contagious anterior segment disease is also recommended. Unit dosages are another viable option for use in pre-operative, post-operative, compromised corneas, and contagious anterior segment disease cases.

CONCLUSION

We investigated the contamination rate and use of multi-drop diagnostic pharmaceutical agent solutions used in primary eyecare settings. While certainly not the only investigation of eyedrop solution containers, this study is the first to examine these particular solutions when used in small, primary eyecare settings. The contamination rate we found was consistent with previous studies performed in large hospital settings or in a controlled laboratory environment. In addition, we were able to get very specific species identification and quantification through the employment of a cellular fatty acid analysis using gas liquid chromatography. Again, this is the first study to identify the microorganism to a species level with actual quantification. One new and unexpected

finding in our investigation was the discovery of small, even microscopic, sized particles around the threads of many of the solution container tips. These friable, dried, residue particles may fall off during medication instillation. These microscopic particles can create a possible contamination risk to patients. The particles when tested would almost always result in a positive culture for microorganisms.

The frequency of contamination for diagnostic ophthalmic solutions from primary care ophthalmologic and optometric practices in the Bay Area was found to be 11.7% in this study. Microorganisms were cultured from a few solutions preserved with BAK suggesting contamination of solutions utilizing this as a preservative. The sources of contamination to the solutions are the patient's eyes, lids, lashes, and hands of the person instilling the drops. Aseptic instillation of eyedrops, proper handling and storage of the solutions are some ways of reducing the frequency of contamination from ophthalmic solutions. Of particular importance is the formation of the small residue particles along the majority of container tips that can serve as a source of contamination if they separate from the container during medication instillation..

Survey Form
DPA Use in Clinical Practice

1. Please list the diagnostic pharmaceutical agents that your office has on hand.

DPA Type	Y/N	Brand Name	Bottle Size (ml)
2.5% Phenylephrine Hydrochloride			
Other sympathomimetics			
0.5% Proparacaine Hydrochloride			
Other anesthetics			
0.5% Tropicamide			
1% Tropicamide			
Other parasympatholytics			
Blinx Ophthalmic Rinse Solution			
Other irrigating solutions			
Other solutions used			

2. How do you store your DPA's? For example; bottles up right or upside down, bottles capped or uncapped, on a shelf at room temperature or in a refrigerator, etc.?

3. Are the bottles recapped in between use and/or at the end of the day?

4. Do office storage habits vary and if so how?

5. How do you determine when to open and use a new bottle of solution? For example; when the bottle is empty, after the expiration date, 3 weeks after opening the bottle, etc.?

6. How many days of use generally occur before opening a new container?

7. Are containers marked and dated when opened for the first time?

8. Who primarily administers the drops in your office, ophthalmologist, optometrist, technician, or staff?

9. What is the method of instillation?

10. Where and how is the container cap placed when drops are administered?

11. What happens to a multi-use bottle that has touched a patients eyes or lashes while administering the drops? For example; is use of that bottle continued or discontinued in general practice, is that bottle discarded and a new container opened, is that bottle's tip and cap cleaned or disinfected, etc.?

12. Are the container tips and caps ever cleaned or disinfected? How and with what are they cleaned or disinfected?

13. If a known infectious patient has drops administered, is that bottle discarded and a new container opened, is that bottle's tip and cap cleaned or disinfected and continued in use for general practice?

14. Does your office use a different set of bottles for pre-operative surgery patients or post-operative surgery patients versus bottles for general use patients and red-eye patients?

Survey Form Results
DPA Use in Clinical Practice

In our study, we attempted to survey each of the 17 practices that we collected samples from by sending a survey form to their clinics. Each questionnaire was anonymous and no identification of the clinic practice was requested. Only 7 of the 17 questionnaires were returned. This might be in part due to the length of the survey and the implicating nature of some of the questions. However, while limited in their numbers the results of these surveys are summarized below.

Question or Response	Number	Percentage
Container stored up right	7	100%
Container stored on side sometimes	2	100%
Container capped	7	100%
Container stored Capped between use	7	100%
Container discarded if expired or discolored	4	57%
Containers marked and dated	3 Yes 4 No	43%Y 57%N
Administration done by practitioner	7	100%
Cap held in hand	2	29%
Cap on counter	6 (1 on tissue on counter)	86%
Tip wiped after contact	2	29%
Container discarded after contact	4	57%
Caps and tips cleaned and disinfected	1 Yes 6No	14%Y 86%N
Discarded after use on known infected patient	7	100%

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